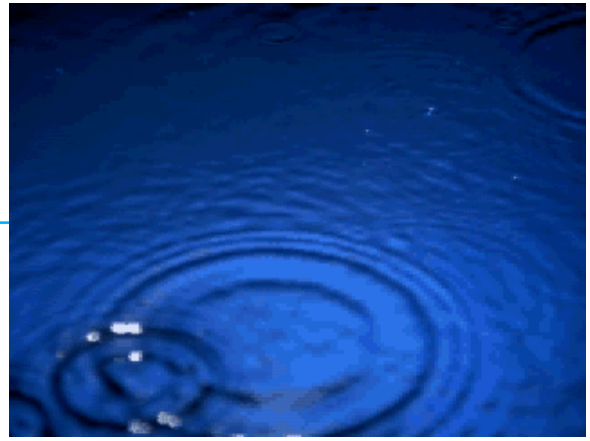
GPM

GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Measurement

System Definition Review
Operations and Ground System Development



Tim Rykowski 301/286-2460

Timothy.B.Rykowski@nasa.gov

Goddard Space Flight Center

December 6-8, 2005

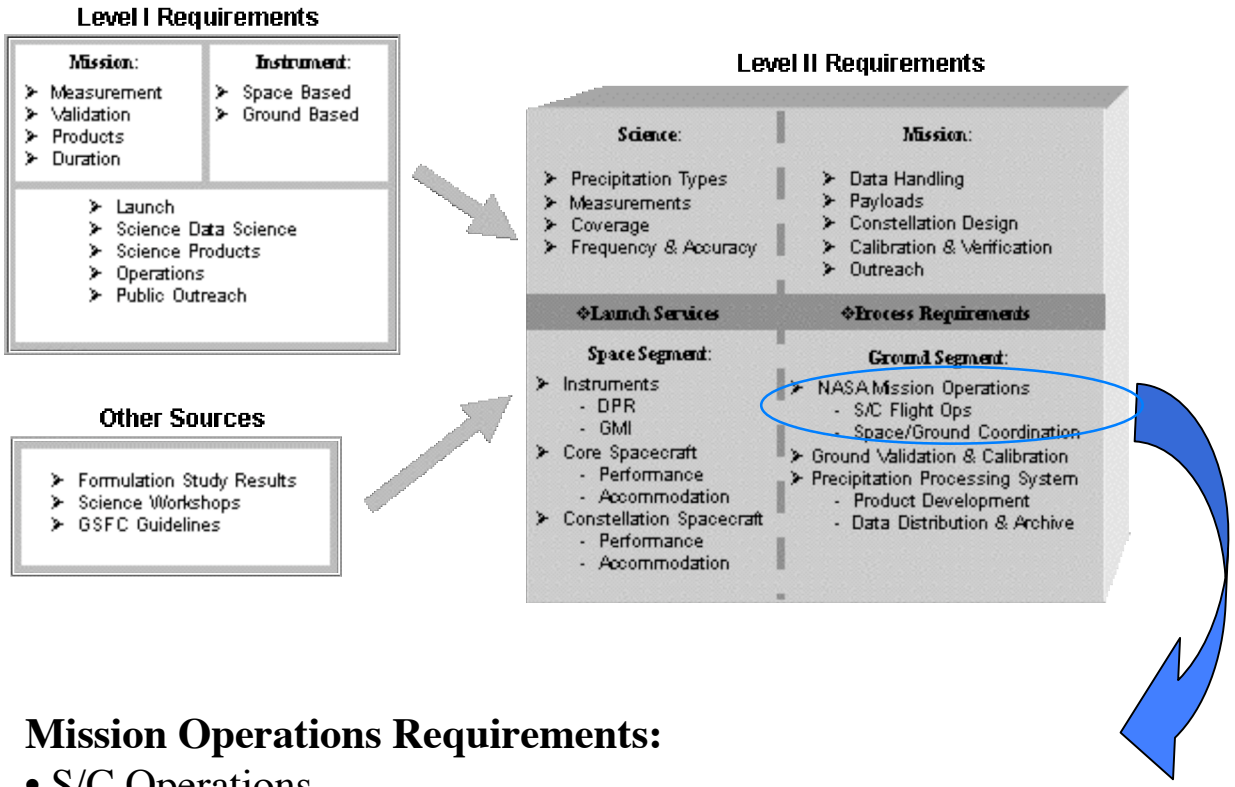
GPM Ground System and Mission Operations Team

• ***Element Lead***	***Tim Rykowski***
• ***Operations Engineering***	***Joseph Howard/HTSI***
• ***Architecture Development***	***David McClure/HTSI*** ***Howard Calk/QSS***
• ***SN Customer Commitment Manager***	***Lynn Myers***
• ***NISN Customer Service Rep***	***Patricia Perrotto/BAH***

Operations and Ground System Development

- ***Agenda***
  - *Driving Requirements*
  - *Changes since June 2002 SRR*
  - *Ground System and MOC Functional Architectures*
  - *Operations Concept*
    - *Routine Operations*
    - *Contingency Operations*
  - *Space Asset Protection*
  - *Ground System/Mission Operations L2 Requirements*
  - *Requirements Verification Strategies*
  - *Technologies Required*
  - *Risks*
  - *Road to PDR*
  - *Schedule*

Mission Operations Requirements Flow



Mission Operations Requirements:

- S/C Operations
  - Health & Safety, CMD & TLM
  - Data Handling
- Instrument Operations
  - Commanding Performance Monitoring
- Space/ Ground Link
  - CMD & TLM Links Performance
  - Contingency Operations

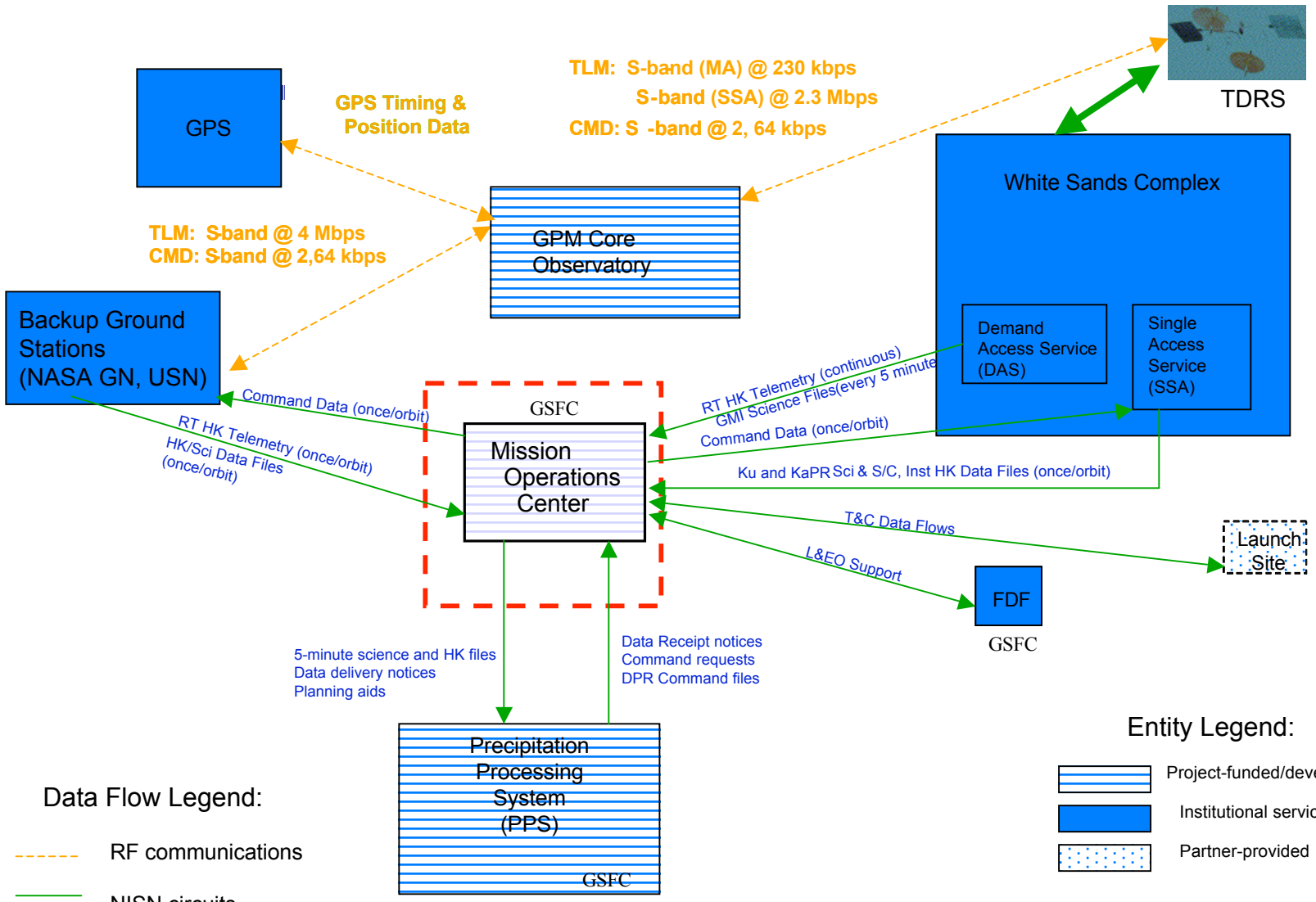
Driving Requirements

- ***Receive, process, and forward mission science data to PPS to support the generation of science products:***
  - *Immediate Precipitation Products (8.2, 8.3)*
    - *Satisfies outreach requirements for Mission*
  - *Research Quality Precipitation Products (2.2.10, 7.2.21)*
    - *48-hour latency, 98% completeness*
- ***Monitor and Control flight operations of GPM Core Observatory and NASA-provided Constellation spacecraft (7.1.15-7.1.33)***
- ***Support Mission Science Availability requirement of 95% (2.2.11)***

Changes Since June 2002 SRR

June 2002 SRR	December 2005 SDR	Rationale for Change
Use IP-based protocols for space-ground communications	Use CCSDS-based protocols for space-ground communications	1. Lowest risk given change from in-house build to Hybrid approach with FFP avionics procurement
Use SN DAS service to return all science data from Core Observatory	Use SN DAS service to return GMI data, SN SSA scheduled service once/orbit to return KuPR and KaPR data	1. Only GMI data is needed to create 1-hour immediate precip. product 2. Can reduce data rate and eliminate interference issues with other DAS users
Space Asset Protection not addressed in concept	1. Authenticate and Encrypt uplink commands 2. Provide geographically separate emergency MOC	1. GPD 7120.1 (SAP policy) effective 5/25/05 2. Results of mission threat assessment conducted by GSFC subject matter expert
Perform orbit maintenance maneuvers autonomously	Perform orbit maintenance maneuvers using FOT, MOC tools	Expansion of control box needed for KuPR, KaPR operations enables expansion of Core spacecraft altitude control box, allows orbit control during 8x5 ops.

Ground System Architecture



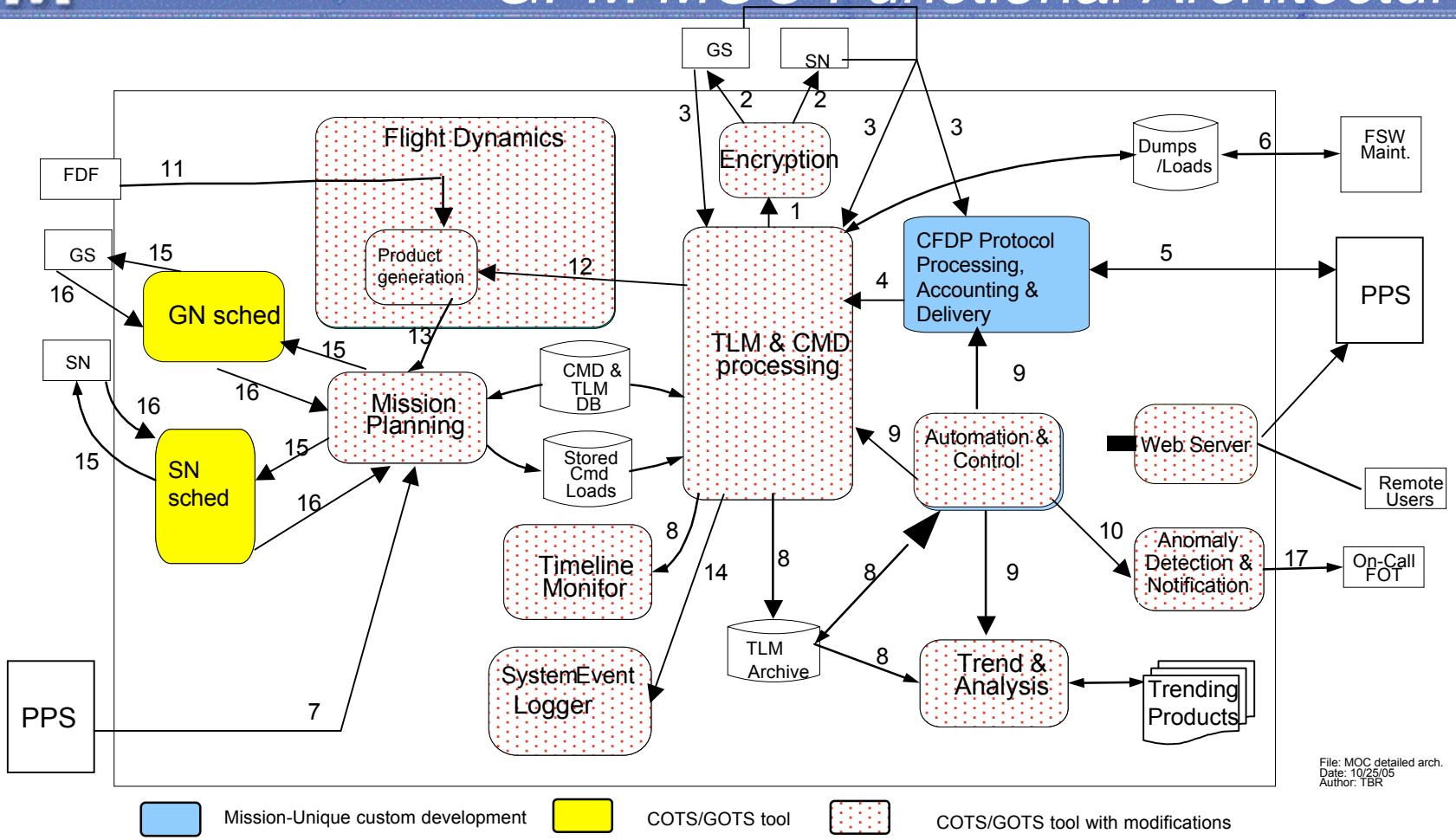
Functional Architecture Element Description (1 of 2)

- ***Tracking Data Relay Satellite System (TDRSS)***
  - *Provides forward link and return link services for GPM Core and Constellation spacecraft through scheduled legacy services*
  - *Provides near-continuous return link capability for GPM Core and Constellation spacecraft via Demand Access Service (DAS)*
- ***TDRSS Ground Terminal (TGT/White Sands, NM)***
  - *Receives return link data from and uplinks forward link data to TDRSS constellation*
  - *Demodulates, bit synchronizes telemetry*
  - *Electronically interfaces with MOC to:*
    - *Receive commands*
    - *Deliver telemetry*
  - *Provides short-term telemetry storage to protect against data loss during communications link outages*
- ***Backup Ground Stations***
  - *Provide similar forward and return link service functionality to TGT*
  - *Used only as a backup in case of catastrophic failure on-board spacecraft (e.g., loss of high-gain antenna) or within SN*
- ***Mission Operations Center (MOC/GSFC)***
  - *Provides all facilities necessary to support spacecraft operations*
    - *Real-time housekeeping data processing*
    - *Health and safety assessment*
    - *Generation, uplink, and verification of commands*
    - *Network, spacecraft, and instrument planning and scheduling*
    - *Flight Dynamics support*

Functional Architecture Element Description (2 of 2)

- ***Mission Operations Center (MOC/GSFC) (continued)***
  - *Receives telemetry from TGT, and performs protocol processing to "close" space-ground file delivery protocol (CFDP)*
  - *Interfaces with PPS to deliver:*
    - *5-minute science instrument files*
    - *5-minute housekeeping data files*
    - *Metadata associated with data processing and delivery*
    - *Ancillary data to support science product generation*
  - *Interfaces with PPS to receive instrument commands, instrument command requests*
- ***Precipitation Processing System (PPS)***
  - *Creates higher-level science data products*
  - *Delivers science data products to user community*
  - *Provides interface to instrument science teams*
  - *Provides data receipt notices for all files delivered by MOC*
  - *Delivers instrument commands, instrument team command requests to MOC*

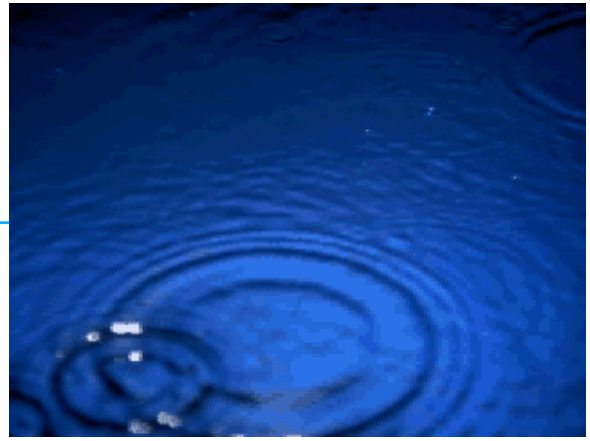
GPM MOC Functional Architecture



GPM MOC Functional Architecture Overview

1. Forward Link Data
2. Encrypted Forward Link Data
3. Return Link Data
4. CFDP Protocol Directives
5. S/C & Inst. Sci/HK Data Files, Data Delivery & Receipt Notices, Ku and KaPR commands
6. SC Command Loads
7. Instrument Command Loads/Requests
8. HK Data
9. Automation Triggers
10. Paging Triggers
11. S/C Position and Velocity
12. GPS Data
13. FD Planning Products
14. Event Messages, Alarms, & Alerts
15. Schedule Request
16. Confirmed Schedules & Status
17. Page notification to operator

Mission Operations Concept



Mission Operations Concept -- Highlights

- ***Mission Operations is straightforward and can be accomplished using an 8x5 staffing profile (day shift, weekday only)***
  - *Limited commanding required*
    - *Instruments operate in survey mode and require little commanding from ground*
    - *Instrument/spacecraft activities can be managed with no more than one command load daily during staffed periods.*
  - *Data Management Operations simplified through use of CCSDS File Delivery Protocol (CFDP)*
    - *Significantly simplifies Solid State Recorder management*
      - *Delivery acknowledgements uplinked from ground segment can be used to control SSR contents*
      - *Retransmissions are automatically performed through uplink of appropriate protocol directives*
      - *Solid-state recorder management does not require labor-intensive effort from FOT personnel.*
  - *Use of Demand Access System simplifies scheduling operations associated with near-continuous return link services needed for mission*
    - *Provided via a single service request to SN prior to the mission*
  - *Similar operations staffing approach used successfully on several current similar missions in operation (such as IMAGE, MAP, SMEX, SWIFT) and development (GLAST)*
  - *Mature technology exists to allow unstaffed operations on off-shifts*
    - *Paging and automation systems available, successfully used on several previous missions.*

Data Delivery Operations Concept (1 of 2)

- ***Core Spacecraft transmits return link telemetry to ground on a near-continuous basis via SN to support GPM requirements for radiometer-based immediate precipitation products***
  - *Demand Access Service (DAS) used to provide near-continuous S-band MA-R service*
  - *Spacecraft and instrument housekeeping telemetry transmitted using CCSDS packets/Virtual Channel Data Units (VCDUs)*
  - *5-minute GMI instrument science files transmitted using CFDP*
  - *R/S Error Detection and Correction (EDAC) included with all return link VCDUs to improve initial transmission quality, minimize requests for CFDP retransmissions*
  - *Core Spacecraft autonomously slews antenna from one TDRS to another to support continuous return link transmission*
    - *No ground commands required to manage antenna pointing*
    - *Short duration (~few minutes) outages are expected when transitioning DAS service between TDRSs due to gimballing of HGA*
      - *Core S/C will suspend file transmissions during TDRS transition periods*

Data Delivery Operations Concept (2 of 2)

- ***Once per orbit, Core spacecraft transmits stored return link telemetry via SN to support Level 1 requirements for radar-based immediate and research precipitation products***
  - *Stored instrument science files are transmitted using CFDP*
  - *All spacecraft and instrument housekeeping data for the preceding orbit are transmitted as 5-minute files using CFDP*
  - *SN communications provided via TDRS S-band Single Access (SSA) service*
- ***Mission Operations Center (MOC) uplinks protocol directives to Core spacecraft to report status of file transmissions***
  - *CFDP protocol directives uplinked once per orbit during scheduled SSA contacts (during unstaffed as well as staffed periods)*
    - *Acknowledgements (ACKs) report the complete receipt of an individual file*
    - *Negative acknowledgements (NACKs) request retransmission of selected file segments which have not been received, or received with errors*

Operations Concept -- Routine Operations (1 of 7)

- ***Routine operations activities described for the following Mission operations:***
  - *Real-time telemetry processing*
  - *Planning and Scheduling*
  - *Commanding*
  - *Flight Dynamics*
  - *Science Data Receipt, Processing and Delivery*
  - *Long-Term Performance Assessment*

Operations Concept -- Routine Operations (2 of 7)

- ***Real-Time Telemetry Processing***
  - *Spacecraft:*
    - *On-board telemetry processing/monitoring is performed for all key spacecraft subsystem and instrument parameters*
    - *FSW employs fault detection/correction software to autonomously respond to critical system failures, including:*
      - *Failover to redundant components*
      - *Entering a low-power state in case of power system anomaly*
      - *Entering safe hold state*
  - *Ground System/MOC:*
    - *Prime shift operations:*
      - *Spacecraft housekeeping data is received near-continuously, and is processed to determine health and safety of spacecraft*
      - *MOC automatically monitors telemetry for out-of-limit conditions*
        - *Appropriate mechanisms are used to notify FOT personnel when limit violations detected*
        - *Spacecraft engineer(s) review data to determine appropriate response to anomalies*
    - *Off-shift operations:*
      - *Spacecraft housekeeping data is received near-continuously, and is processed to determine health and safety of spacecraft*
      - *On-call FOT personnel are automatically paged upon occurrence of pre-defined out-of-limit condition*
      - *Paging rules can be re-configured/modified by operations personnel as required*

Operations Concept -- Routine Operations (3 of 7)

- ***Planning and Scheduling***
  - *Instrument operations:*
    - *Planned by instrument teams in coordination with project scientist*
    - ***KuPR/KaPR instrument operations***
      - ***Instrument calibrations***
        - ***Internal calibrations expected monthly***
        - ***External calibrations requiring yaw maneuver expected twice yearly***
      - ***Software changes, table loads (expected infrequently)***
    - ***No routine commanding of GMI instrument is expected***
      - ***Infrequent software modifications or table loads are possible***
      - ***Infrequent instrument calibrations may be required***
    - *All special instrument operations/commands are coordinated via PPS and delivered to the MOC*
  - *Spacecraft operations:*
    - *Planned by spacecraft engineer(s) within MOC*
    - *Most significant operations effort will be in scheduling/managing SN services (SSA contacts required once an orbit)*
  - *Integrated timeline created by MOC planners to integrate spacecraft and instrument plans*
    - *Conflicts, if any, are identified, and resolved with instrument teams via PPS (conflicts are expected to rarely occur)*
  - *Ground system:*
    - *Schedule requests for forward link, return link services are coordinated by MOC planners through Data Services Management Center*
      - *Forward link services scheduled include normal command load activity plus retransmission requests*

Operations Concept -- Routine Operations (4 of 7)

- ***Commanding:***
  - *Spacecraft/instrument operations:*
    - *MOC personnel create/format command loads and uplink them during a scheduled TDRSS forward link session*
    - ***Instrument command operations concept very similar to TRMM***
      - *Simple instrument commands are directly generated by MOC personnel after coordination with instrument team/PPS*
      - *More complicated instrument commands (such as software uploads) are created directly by instrument teams, delivered to PPS, and subsequently sent to MOC, where they are integrated with spacecraft command loads*
        - *Need for these types of commands should be infrequent*
    - *Command load frequency expected to be no more than once daily during staffed operations*
    - *Spacecraft/instrument commands require "person-in-the-loop" to initiate uplink*
  - *CFDP protocol directives:*
    - ***Commands are automatically generated by CFDP ground software, and uplinked every orbit per TDRSS SSA schedule***
      - *Commands acknowledge completely received files, and request retransmission of lost or damaged file segments*
    - ***CFDP protocol directives are delivered autonomously to spacecraft, without "person-in-the-loop"***
  - *Security*
    - ***All commands are encrypted in MOC, and decrypted/authenticated by the Core Spacecraft***

Operations Concept -- Routine Operations (5 of 7)

- ***Flight Dynamics:***
  - *Flight Dynamics functions performed by Core spacecraft include:*
    - *Definitive orbit determination through GPS sensors.*
    - *Definitive attitude determination through attitude sensors*
  - *FOT personnel perform following activities:*
    - *Calculating predicted orbit for use in determining advance TDRSS schedules, and use by PPS*
    - *Planning maneuvers:*
      - *Orbit raising maneuvers to maintain mission altitude (expected ~weekly)*
      - *Yaw maneuvers:*
        - *As part of orbit raising maneuvers (given propulsion concept)*
        - *To maintain solar array pointing (~ monthly)*
        - *As required to support instrument calibrations*

Operations Concept -- Routine Operations (6 of 7)

- ***Data Receipt***
  - *FOT personnel monitor quality of TDRSS downlink using TDRSS status information as well as quality/accounting data internal to the MOC*
    - *FOT personnel are paged to respond to significant downlink problems if anomalies occur on off-shifts*
  - *FOT personnel coordinate with TDRSS operators as necessary to resolve large outages*

- ***Data Processing and Delivery***
  - *Return link processing and delivery to PPS occurs automatically, requiring no FOT intervention*
    - *Metadata exchange (delivery notices from MOC to PPS, data receipts from PPS to MOC) supports automation of file ingest and accounting operations for both sides of interface*
  - *FOT personnel coordinate with PPS, NISN personnel to resolve communications problems when necessary*
  - *FOT personnel initiate manual procedures to re-deliver science data to the PPS, to recover from PPS operational problems*

Operations Concept -- Routine Operations (7 of 7)

- ***Long Term Performance Assessment:***
  - *Spacecraft housekeeping data stored at MOC for the life of the mission*
  - *Spacecraft engineers investigate long-term performance trends for all major subsystems, develop operational workarounds or procedures as necessary to avoid future spacecraft anomalies where possible*

Operations Concept -- Contingency Operations

- ***Clock Correction***
  - *Time is normally controlled on-board spacecraft through use of GPS receiver*
  - *Backup procedures will be in place in MOC to perform clock correction upon failure of GPS receivers (specific method TBD)*
- ***Orbit Determination***
  - *On-board orbit determination normally provided via GPS receiver*
  - *Backup orbit determination can be provided via NORAD, TDRSS Differenced One-Way Doppler (DOWD), or Wallops C-band skin tracks if GPS receivers fail*
    - *Specific method(s) to be chosen by PDR*
- ***Backup communications***
  - *NASA or Commercial GN stations can be used if communications unavailable via SN due to:*
    - *Extended duration SN failure*
    - *HGA failure on-board Core spacecraft*
  - *Ground network will be assembled when failure occurs or is imminent*
  - *Mission data recovery is degraded with the GN approach to a "best effort" recovery*
    - *Immediate precipitation product latency requirements will not be satisfied all the time*
      - *Continuous return link telemetry not possible at planned mission orbit*
      - *Ability to schedule one contact per orbit (required to recover science data) problematic due to visibility constraints, probable support conflicts*

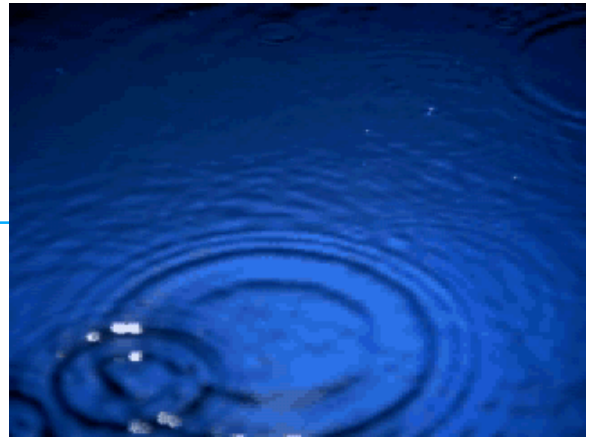
Space Asset Protection

- ***Process:***
  - *Threat Assessment for GPM Core and Constellation spacecraft completed by GSFC subject matter expert September 2005*
- ***Summary of results:***

Threat	Mitigation Strategy
Unauthorized commands to Core/Constellation spacecraft	***1. Protect command link by implementing encryption/authentication strategy*** ***2. Control access to data/documentation describing commanding information***
Extended loss of primary Mission Operations Center	***Establish geographically-separated backup MOC***

Additional details, if necessary, can be provided in a classified briefing

Ground System/Mission Operations L2 Requirements



Mission Operations Requirements - 1

- ***Space Network Requirements:***
  - *Provide continuous return link coverage for NASA GPM spacecraft (7.1.1)*
  - *Provide scheduled forward and return link services for NASA GPM spacecraft (7.1.2)*
  - *Provide return link data to mission operations in real time (7.1.3)*
  - *Record and retain all telemetry data for at least 72 hours (7.1.4)*
  - *Retransmit recorded data to mission operations upon request (7.1.5)*
  - *Service proficiency of 99.9% (7.1.6)*
  - *Provide personnel and facilities to support pre-launch interface and system test activities (7.1.7)*

Mission Operations Requirements - 2

- ***Ground Network Requirements:***
  - *Provide scheduled forward and return link services to support launch/early orbit and contingency operations (7.1.8)*
  - *Deliver real-time housekeeping telemetry to mission operations within 5 seconds of receipt (7.1.9)*
  - *Deliver recorded science and housekeeping telemetry to mission operations within 24 hours (7.1.10)*
  - *Record and retain all telemetry data for at least 72 hours (7.1.11)*
  - *Retransmit recorded data to mission operations upon request (7.1.12)*
  - *Service proficiency of 99.1% (7.1.13)*
  - *Provide personnel and facilities to support pre-launch interface and system test activities (7.1.14)*

Mission Operations Requirements - 3

- ***Interface Requirements:***
  - *Interface with space/ground link to send commands, receive telemetry, and exchange supporting information (7.1.15)*
  - *Electronically deliver science and housekeeping files to PPS to satisfy product latency requirements (7.1.18)*
    - *Initiate electronic delivery of science and housekeeping files to PPS automatically upon their assembly at the MOC (7.1.33)*
  - *Electronically deliver science and housekeeping files to PPS to recover lost data within 30 days of original transmission (7.1.19)*
  - *Receive instrument schedule requests and command loads controlling instrument operations from PPS (7.1.20)*
  - *Coordinate special operations (I.e., anomaly investigations) with instrument operations teams via the PPS (7.1.25)*
  - *Provide mission planning and ancillary data to the PPS (7.1.21)*
  - *Interface with Flight Dynamics Facility to support L&EO flight dynamics activities (7.1.16)*
  - *Interface to Launch sites to send commands to/receive telemetry from NASA GPM spacecraft while on the pad (7.1.17)*

Mission Operations Requirements - 4

- ***Mission Operations Center – Functional Requirements***
  - *Monitor the health and safety of NASA GPM spacecraft and their instruments (7.1.22)*
  - *Schedule spacecraft and instrument activities for NASA GPM spacecraft (7.1.26)*
  - *Produce predicted orbit information, maintain orbit altitude, and verify spacecraft attitude for NASA GPM spacecraft (7.1.27)*
  - *Evaluate the short and long-term performance of the NASA GPM spacecraft (7.1.29)*
    - *Provide sufficient storage for spacecraft housekeeping telemetry to support spacecraft performance evaluation (7.1.28)*
  - *Generate all commands to be transmitted to NASA GPM spacecraft (7.1.30)*
  - *Collect science data quality and accounting statistics for the NASA GPM spacecraft for the mission lifetime (7.1.32)*
  - *Maintain flight software for all NASA GPM spacecraft during operations (7.1.31)*
  - *Implement the ground component of the CFDP protocol (7.1.24)*

Mission Operations Requirements - 5

- ***Mission Operations Center – Functional Requirements (continued)***
  - *Provide staffing to support operations activities (7.1.36)*
  - *Provide automated operations during unstaffed periods (7.1.37)*
  - *Provide test tools to simulate NASA GPM spacecraft uplink and downlink formats, and to verify MOC performance (7.1.34)*
  - *Support spacecraft, instrument, end-to-end, and pre-launch test activities (7.1.35)*
  - *Satisfy NPR 2810.1 security requirements for the Mission information category (7.1.23)*

Mission Operations Requirements - 6

- ***Mission Operations Center – Performance Requirements:***
  - *Availability of at least 99.95% for critical operations (7.1.38)*
  - *Availability of at least 98% for normal operations (7.1.39)*
  - *Allowable data loss of 1% or less (7.1.41)*
  - *Provide concurrent support to operations, test, and maintenance activities (7.1.40)*

Mission Operations -- Requirements Verification Strategies

- ***Full testing lifecycle will be used to verify MOC/Ground System performance prior to launch***
- ***Appropriate test plans/procedures will be documented for each phase of testing***
- ***Ground System Testing goal is to verify performance, functionality of each Ground System Element, and includes:***
  - *Developer level testing for each component*
  - *Formal acceptance testing of each subsystem*
  - *Network compatibility tests*
- ***Spacecraft-Ground System interface test goal is to ensure compatibility of spacecraft-ground system interfaces, and includes:***
  - *Tests with spacecraft simulator*
  - *Spacecraft interface tests (hardline to S/C)*
  - *Thermal vac tests*
- ***Operations Readiness Testing goal is to ensure readiness of FOT personnel and procedures prior to launch, and includes:***
  - *Operations readiness exercises, formal mission operations readiness tests*

Mission Operations -- Technologies Required

- ***No new technology development is required for GPM***
  - *CFDP successfully used on previous missions (Messenger, Deep Impact)*
    - *Lunar Reconnaissance Orbiter (LRO) also planning to implement CFDP*
  - *GSFC software prototype exists which can be leveraged for GPM*

- ***COTS/GOTS systems exist which will satisfy bulk of requirements for core MOC functionality – successfully used in several previous missions***

- ***Automation/remote access technologies required, and in use in existing control centers, include the following:***
  - *Paging support (to notify on-call personnel of anomalies, critical events)*
  - *Remote access to certain control center functions (i.e., trending system) through WWW*
  - *Automation of "routine" mission operations activities, such as*
    - *Delivery of data to PPS*
    - *Creation of trending products*
    - *Creation of flight dynamics products*

Risk Summary

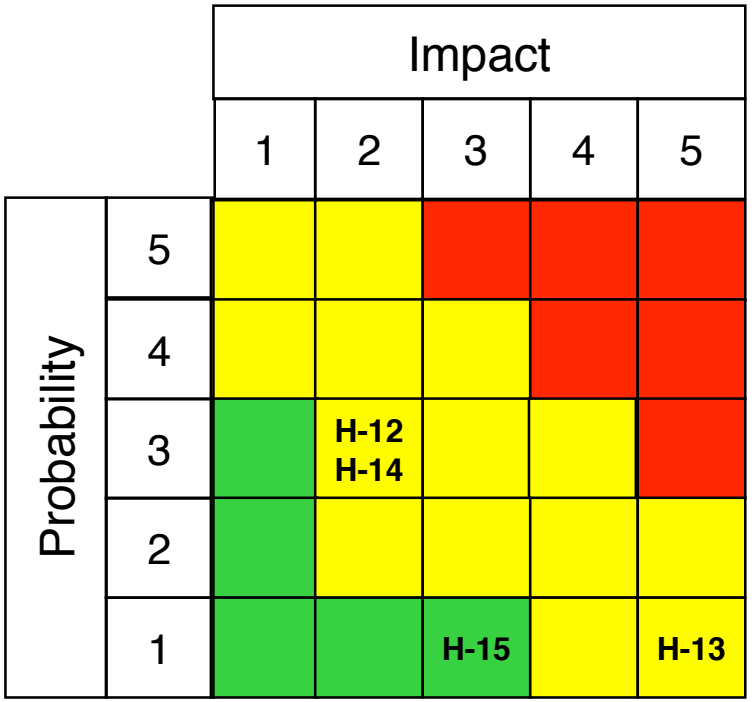
Risk Title

H-12 DAS Obsolescence for GPM

H-13 Core Spacecraft/NASA GN Compatibility

H-14 DAS Configuration for GPM

H-15 Avionics Package Operations Preparation



Risks (1 of 2)

- ***DAS Configuration for GPM (H-14)***
  - *Current DAS contains obsolete equipment, and system performance when supporting multiple users unproven. Concern documented to SN in DAS IRT report*
    - *Mitigation strategy:*
      - *Monitor progress of DAS performance during 2006, monitor progress of system expansion for GLAST support when initiated*
    - *Contingency plan:*
      - *Use legacy MA services to satisfy mission requirement*
        - *Additional ops scheduling burden, potential impact to ops staff size*
        - *Additional gaps in near-continuous coverage possible due to support conflicts*
    - *Need to make DAS/Legacy MA decision ~2 years before launch*
- ***DAS Obsolescence for GPM (H-12)***
  - *Current DAS not compatible with next generation TDRSs, and current generation (TDRS 1-7) TDRSs will be 17-27 years old by GPM launch. Concern documented to SN in DAS IRT report*
    - *Mitigation strategy:*
      - *Monitor progress of technology upgrade activities when funding secured by SN*
    - *Contingency plan:*
      - *Use legacy MA services to satisfy mission requirement.*
        - *Additional ops scheduling burden, potential impact to ops staff size*
        - *Additional gaps in near-continuous coverage possible due to support conflicts*
    - *Need to make DAS/Legacy MA decision ~2 years before launch*

Risks (2 of 2)

- ***Core Spacecraft – NASA GN Compatibility (H-13)***
  - *NASA GN sites currently do not support S-band return link data with QPSK modulation*
  - *Mitigation Strategy:*
    - *Monitor progress of receiver upgrades @ GN locations. Wallops upgrades purchased, Alaska and Svalbard upgrades planned for next year*
  - *Contingency Plan:*
    - *Use only commercial network(s) for backup support. Mission will occur additional operations costs*
  - *Upgrades must be completed ~2 years before launch to support RF compatibility tests*
- ***Avionics Package Operations Preparation (H-15)***
  - *Portions of AP flight software will be vendor-proprietary, and may be difficult for operations team to gain adequate knowledge about software to support mission ops*
  - *Mitigation Strategy:*
    - *Ensure that AP implementation contract contains clauses directing AP vendor to:*
      - *provide ops training, ops documentation*
      - *allow for FOT attendance during AP testing at vendor site*

Road to PDR

- ***Core Spacecraft Ground Segment Activities:***
  - *Complete requirements development/decomposition for ground system/mission operations center*
    - *Complete L3 ground system specification and L4 MOC requirements*
  - *Complete Core Spacecraft operations concept*
    - *Draft exists and has been peer reviewed*
  - *Develop functional and physical ground segment/MOC architecture*
    - *Perform trade studies to select COTS/GOTS/OTS packages*
      - *Make preliminary selection for all COTS/GOTS/OTS tools*
        - *Final selection of T&C system after Avionics Vendor selection*
        - *Final selection of other tools @ CDR*
    - *Provide top-level design for custom components*
    - *Develop preliminary bill of material*
    - *Produce preliminary version of design specification*
  - *Develop Ground System product development plans (Ground System product development handbook, MOC implementation plan)*
  - *Develop preliminary versions of Interface Control Documents (ICDs)*
  - *Develop preliminary version of Ground System Verification Plan*
  - *Develop preliminary versions of required security documents*
- ***Constellation Spacecraft Ground Segment Activities***
  - *Develop top-level concept and system cost (leverage IMDC results)*
- ***Peer Reviews:***
  - *L3 Ground System Requirements peer review: February 2006*
  - *MOC preliminary design peer review: July 2006*

Documentation (1 of 3)

Document Name	Rqs. Peer Review	MOC Design peer review/Mission PDR	Status as of 11/28/2005
Ground System Product Development Handbook	Draft	Baseline	Draft exists
MOC System Development Plan		Draft	
Core Spacecraft Operations Concept Document	Draft	Baseline	Draft exists
GPM Ground System Requirements Document	Draft	Baseline	Draft exists
GPM Ground System Accommodations Specification	Draft	Baseline	Draft exists. Will eventually be superceded by Core S/C space-ground ICD
MOC Level 4 requirements specification	Preliminary	Draft	Initial draft exists

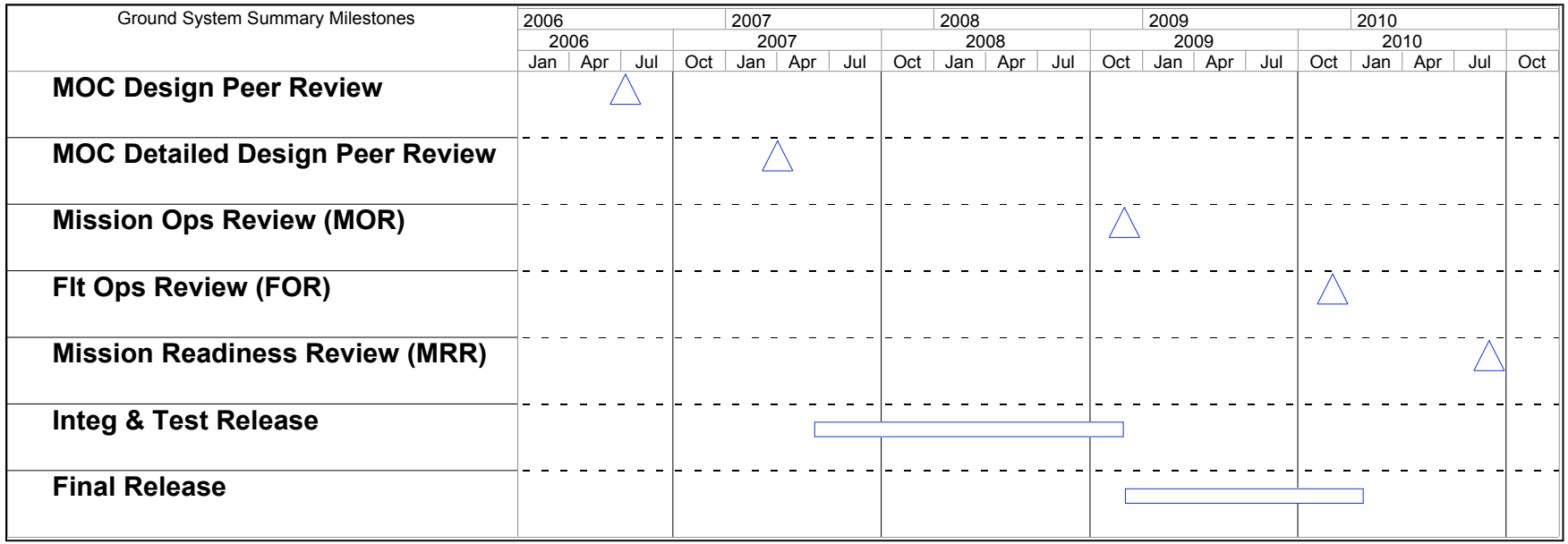
Documentation (2 of 3)

Document Name	Rqs. Peer Review	MOC Design peer review/Mission PDR	Status as of 11/27/2005
MOC-PPS ICD		Preliminary	Initial draft exists
DAS-Customer ICD		Preliminary	Baseline exists – 450/Institutional ICD
NCCDS-MOC ICD		Preliminary	Baseline exists – 450 Institutional ICD
MOC-FDF ICD		Preliminary	Initial draft exists

Documentation (3 of 3)

Document Name	Rqs. Peer Review	MOC Design peer review/Mission PDR	Status as of 11/27/2005
MOC Design Specification		Preliminary	Initial internal draft exists. Identifies top-level functional architecture only.
GS Verification Plan		Preliminary	
IT Security Plan		Preliminary	Draft of "boiler plate" sections exists
IT Security Contingency Plan		Preliminary	Draft of "boiler plate" sections exists
IT Risk Management Plan		Preliminary	Initial risk assessment data captured in Excel spreadsheets

Ground Systems Segment
Summary Schedule (to Launch)



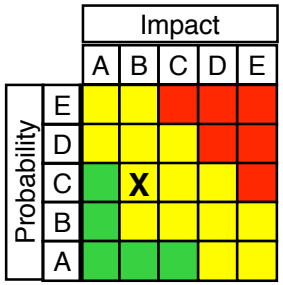
H-12: DAS Obsolescence for GPM

Risk Statement: Given that the current TDRS satellites will be 17-27 years old when GPM Core launches, that they are guaranteed only through 2012 and increasingly likely to fail during GPM operational lifetime, and that the next generation TDRS' (HIJ) MA service beamforming is incompatible with DAS beamformers; it is possible that unless the incompatibility is resolved, GPM mission operations could experience both additional cost to obtain near-real-time data processing services and a degraded quality of service.

If no ground-based beamforming solution is developed within DAS to acquire MA signals from the next generation satellites, then GPM will be forced to use "legacy" MA services to satisfy its near-real-time science requirements. Use of legacy MA services will create a much larger scheduling problem for GPM Mission Operations, and may result in additional data outages due to the limited amount of available legacy MA ground-support equipment.

Risk Data:

Level: Element (Ops/Gnd Sys)



Owner: Tim Rykowski

Timeframe: Long-Term

Mitigation: The DAS Independent Review Team (IRT) recommended prototype development to provide a "proof-of-concept" of the concepts developed within Code 454 addressing the TDRS HIJ incompatibility issue. Track progress of the prototype development and evaluate results until GPM Mission CDR. A decision need not be made by CDR but should be made by Observatory I&T.

Contingency: Plan to use MA legacy services for the GPM Mission. Prior to Mission PDR, operations will do the following:

1--Evaluate the additional operational workload required (and related cost) to explicitly schedule MA legacy services during the mission lifetime.

2--Conduct a loading study with SN operations in an attempt to estimate the availability percentage of the legacy MA service to the GPM Mission--when other operational missions in the 2011-2015 timeframe are considered.

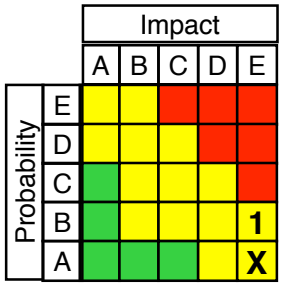
H-13: Core Spacecraft/NASA GN Compatibility

Risk Statement: Given that GPM will rely on the NASA ground network (GN) for backup operations and requires Quadrature-Phase Shift Keying (QPSK) modulation and that the GN requires upgrades to support QPSK; there is potential for a significant ($1.5M) cost impact to the GPM program to fund the upgrades if institutional funding is not provided.

The GPM core spacecraft has baselined a communications design which would use the S-band frequency band, and the Quadrature-Phase Shift Keying (QPSK) modulation scheme. GPM requires this design to satisfy the frequency bandwidth limitations imposed for earth observing S-band users, and to provide sufficient bandwidth for science data transmission. If no institutional or project-directed investment is made to upgrade the NASA GN sites, then the project would be forced to use commercial networks such as Universal Space Network (USN) for backup operations. Costs of using a commercial network could run as high as $3 million annually, while NASA GN operations costs are currently provided free of charge to NASA missions.

Risk Data:

Level: Mission



Owner: Tim Rykowski

Timeframe: Long-Term

Mitigation: Watch risk for now -- work with NASA GN representatives to have modifications performed using GN "technology development" funds rather than GPM project-specific funds. Decision to be made by CDR.

Contingency: Use project-specific contingency funds to develop the GN site modifications required.

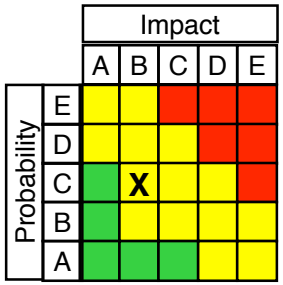
H-14: DAS Configuration for GPM

Risk Statement: Given that the currently operational DAS system contains obsolete hardware for critical components, limited capacity, and an uncertain reliability record when supporting multiple customers simultaneously; unless these issues are resolved through a re-engineering effort, GPM mission operations could experience both additional cost to obtain near-real-time data processing services and a degraded quality of service.

If the current DAS system is not re-engineered and re-qualified with new ground-based beamformers and receivers, expanded with additional customer strings, and re-qualified through comprehensive tests simulating multiple users , then GPM may be forced to use "legacy" MA services to satisfy its near-real-time science requirements. Use of legacy MA services will create a much larger scheduling problem for GPM Mission Operations, and may result in additional data outages due to the limited amount of available legacy MA ground-support equipment.

Risk Data:

Level: Element (Ops/Gnd Sys)



Owner: Tim Rykowski

Timeframe: Long-Term

Mitigation: The DAS Independent Review Team (IRT) recommended an 18-24 month re-engineering activity be initiated to resolve the identified obsolescence, capacity, and reliability issues. Track progress of the re-engineering activities and evaluate results until GPM Mission CDR. A decision need not be made by CDR but should be made by Observatory I & T.

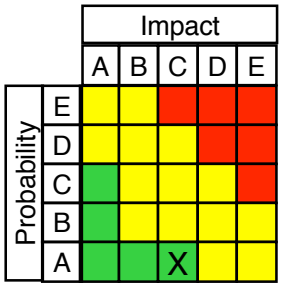
Contingency: Plan to use MA legacy services for the GPM Mission. Prior to Mission PDR, operations will do the following:
1--Evaluate the additional operational workload required (and related cost) to explicitly schedule MA legacy services during the mission lifetime.
2--Conduct a loading study with SN operations in an attempt to estimate the availability percentage of the legacy MA service to the GPM Mission--when other operational missions in the 2011-2015 timeframe are considered.

H-15: Avionics Package Operations Preparation

Risk Statement: Given that the GPM Core spacecraft avionics package (AP) will be provided by an RSDO vendor and contain proprietary software; it is possible that the GPM Operations and Ground Systems Team may not receive all of the necessary information from the vendor to ensure adequate operation of the spacecraft prior to delivery.

Risk Data:

Level: Element (Ops/ Ground Systems)



Owner: Tim Rykowski and Steve Horowitz

Timeframe: Mid-Term

Mitigation: Include provisions in the Implementation Contract for a GSFC GPM team to attend the AP testing at the vendor site and for the AP vendor to provide extensive training and documentation describing AP operations. Include provisions in the Implementation Contract to ensure close coordination between the AP vendor and the FOT for procedure. Work closely with previous missions utilizing the RSDO contract vehicle to ensure proper wording of contract provisions.

Contingency:

Agenda

Day 2 - December 7, 2005
Location: NASA GSFC B16W-N76/80

Time	Section	Event	Presenter
8:30 AM	12	Core Spacecraft Management	Horowitz
9:30 AM	13	Primary Spacecraft Systems Engineering	O'Neill
11:00 AM		**Break**	
11:15 AM	14	Mission Operations System Concept/Requirements	Rykowski
12:15 PM		**Lunch**	
1:15 PM	15	Precipitation Processing System Concept/Requirements	Stocker
2:15 PM	16	Ground Validation	Schwaller
3:15 PM		**Break**	
3:30 PM	17	Risk Assessment	Durning
3:45 PM	18	Review Wrap Up	Durning/Ho
4:00 PM		Review Team Caucus	
4:15 PM		**End of Day 2**	